AIRFLOW AND RAINFALL IN CALIFORNIA, DECEMBER 1-5, 1951

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INTRODUCTION

Widespread rainfall in California during the first 5 days of December, 1951, was associated with a rapid succession of storms moving across the Pacific Ocean under the influence of a broad westerly flow. This type of situation transports a great quantity of moist air into California in a direction normal to the mountain ranges. As a result, the degree, or intensity, of the horizontal convergence and lifting is greater than normally associated with a cyclonic circulation.

The following paragraphs will discuss the surface and 700-mb. synoptic picture during this period and will describe the effects of the southward drift of the strong westerlies upon the precipitation pattern.

SURFACE WEATHER

On December 1, 1951, at 0630 GMT, an occulsion lay along the coast of California with four waves to the west of it between 135° and 160° W. longitude. Figure 1 shows the surface weather map some 18 hours later, when the second wave, now partially occluded, was approaching the western coast of the United States. An important feature of the map is the wide belt of westerly winds to the west of the advancing storm. During the following 24 hours the High over the State moved inland so that the

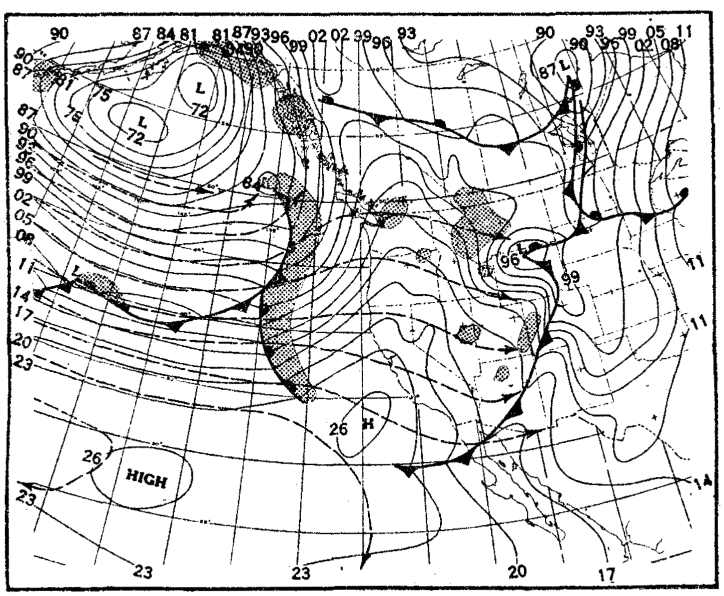

FIGURE 1.—Surface chart, 1830 GMT, December 2, 1951. Shading indicates areas of active precipitation. Superimposed dashed lines show airflow parallel to 700-mb. contour lines (at 1500 GMT).

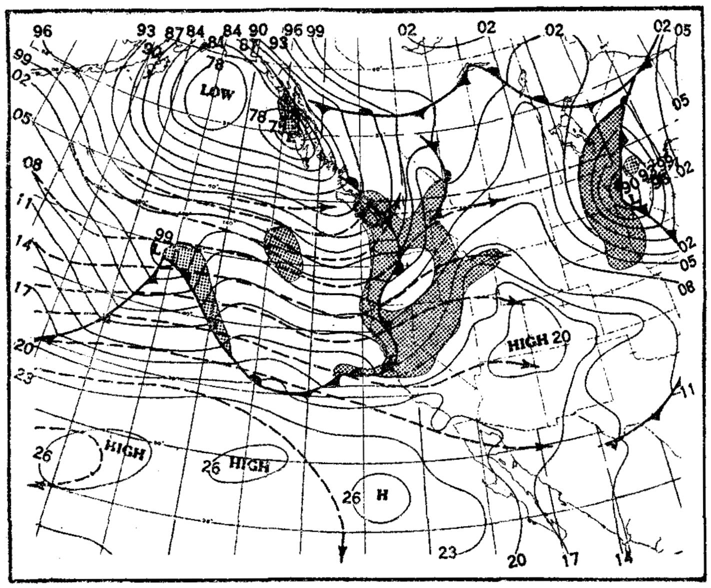

FIGURE 2.—Surface chart, 1830 GMT, December 3, 1951.

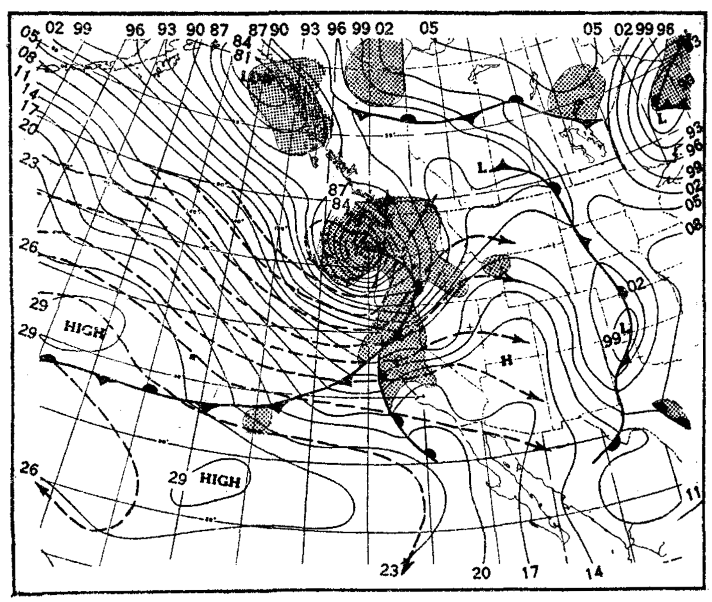

FIGURE 3.—Surface chart, 1830 GMT, December 4, 1951.

TABLE 1.—*Daily total rainfall and prevailing wind directions at sea level for selected stations in California*

Station	Dec. 1		Dec. 2		Dec. 3		Dec. 4		Dec. 5		5 day total fall (inches)	Percent of normal monthly fall
	Rain	Wind	Rain	Wind	Rain	Wind	Rain	Wind	Rain	Wind		
California												
Los Angeles	0.68	E	----------	N	T	E	0.82	E	0.20	NW	1.70	65
Oakland	1.86	SSE	0.07	SSE	1.43	SE	.99	SE	.05	NW	4.40	130
San Francisco	1.59	SW	.22	S	1.58	W	.68	W	.07	NW	4.14	150
Eureka	1.48	S	.26	S	.22	S	.60	S	.90	S	3.46	55

belt of westerly winds extended from longitude 150° W. to northern California (fig. 2).

The map of December 4 (fig. 3) shows that a southeastward moving mass of cold air had begun to invade the coastal sections of Oregon and Washington. On this day the pressure rose quite generally over the northeastern Pacific Ocean as the regime of rain-bearing westerly winds came to an end. On the following day, the fetch of northwest winds extended from Los Angeles to the Aleutian Chain.

The rainfall amounts for four selected stations (table 1) are considerable and fairly representative of the rainfall over the State during the 5-day period. The disruptive influence of the rugged terrain upon the surface wind direction is well illustrated by this table. In contrast, the winds above Oakland, at the 700-mb. level (table 2) are more representative and tend to underscore the association between the west-to-southwest winds and the occurrence of rain.

TABLE 2.—*Wind direction and speed at 700 mb., Oakland, Calif.*

Time (GMT)	Dec. 1		Dec. 2		Dec. 3		Dec. 4		Dec. 5	
	15	03	15	03	15	03	15	03	15	03
Wind direction	WSW	SW	WNW	WNW	WSW	NW	W	W	NW	NW
Speed (knots)	40	50	35	15	20	50	60	45	30	20

Figures 4 to 6 are presented to give a more general picture of the rainfall pattern over the Far West. They also show the spread of the rain area as the belt of strong westerly winds moved southward. An over-all picture of the pressure distribution aloft during the first 5 days of December is provided by figure 7, which shows the departure from normal of the 700-mb. heights. Strong westerly flow relative to normal is suggested by the arrangement of isopleths of departure. (See the preceding article by Klein.)

INFLUENCE OF THE 700-MB. FLOW

In the preceding section it was pointed out that the broad band of westerly winds was an important feature of the surface weather maps. By inspection alone, it can be seen that the rainfall ceased when the winds shifted to northwest. But an even clearer picture of the airflow from one day to the next is gained by superimposing the 700-mb. flow upon the surface map. This method brings into sharper focus the transport of air masses represented only partially by the surface map, and makes it somewhat easier to interpret the surface map.

Once again by reference to figure 1, the striking feature of the weather map is the band of westerly flow which becomes even more important when seen in relation to the upper flow. At once it becomes evident that the westerly winds had a considerably longer fetch than was apparent at the surface. Moreover, this band of winds had already reached the coastline of northern California. At mid-morning, local time, the skies were clear over the State as the rapidly moving ridge moved eastward beneath an area of diverging upper winds. Off the coast of northern California in the vicinity of 128° W., some ships reported a cloud cover just under the area where the upper flow becomes less anti-cyclonic in curvature.

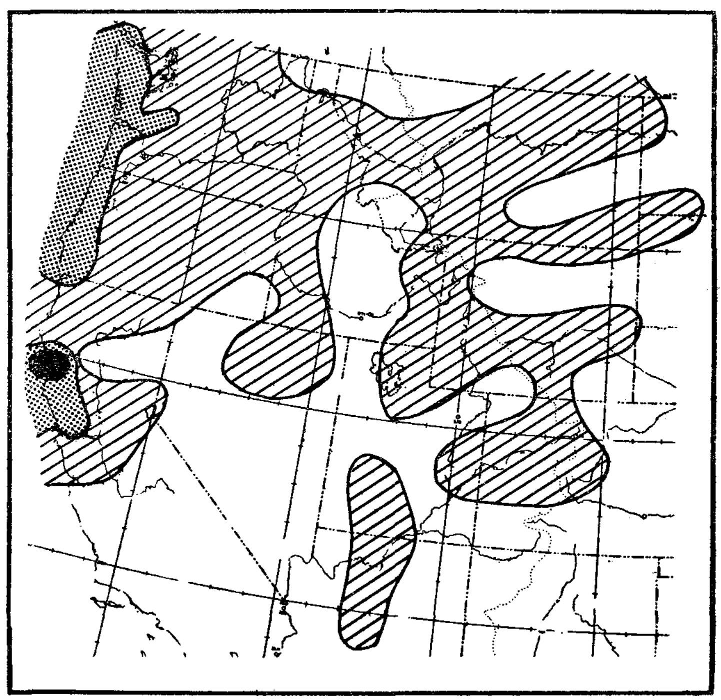

FIGURE 4.—Precipitation chart for 24 hours ending 1230 GMT, December 3, 1951. Slant lines indicate trace to less than 0.5 in.; stipple, 0.5 in. to less than 1 in.; and black, 1 in. or above. (Maps prepared by the River Services Section.)

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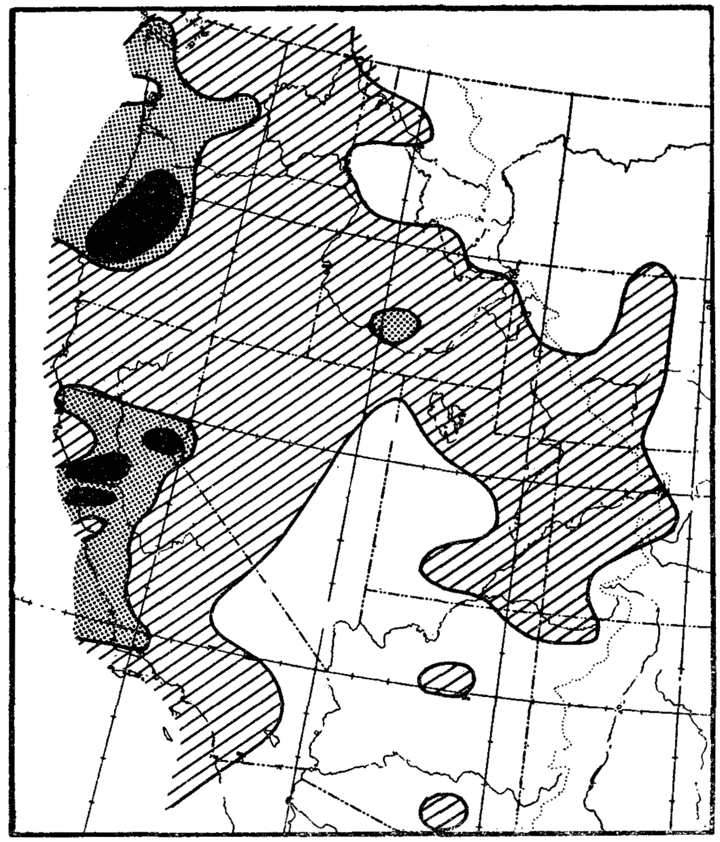

FIGURE 5.—Precipitation chart for 24 hours ending 1230 GMT, December 4, 1951.

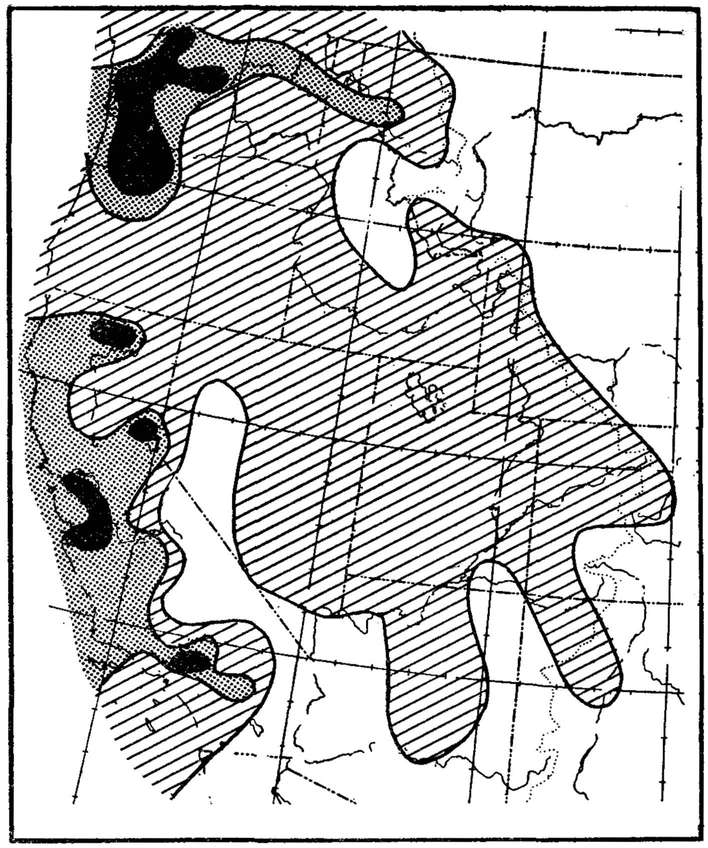

FIGURE 6.—Precipitation chart for 24 hours ending 1230 GMT, December 5, 1951.

As with the surface flow, the upper contours indicated that an area of convergent flow would advance eastward toward the United States during the next 24 hours. Also, the upper airflow showed a strong belt of winds north of latitude 35° N., which would carry the rain area on a course slightly north of east and north of 35° N. The rainfall map for the following 24 hours (fig. 4) shows that this happened, and underscores the indications from the flow that the greatest eastward advance of the rain area would be over Washington and Oregon.

On December 3 (fig. 2) it became evident that not only had the strong upper flow continued but that the winds had increased in speed. The strong cyclonic curvature of the contours observed along the northern half of the Pacific coast had decreased in intensity to the south. However, the westerly winds were stronger between 35° and 40° N. than they were 24 hours earlier. West of the front the rainfall was orographic in origin as can be deduced by noting that the coastal stations reported no rain in progress. East of the front the areas of rainfall and cloud cover nearly coincided. Both ceased abruptly to the east of 112° W. where the upper flow was diverging rapidly.

Figure 5 does not show any great difference from figure 4, in so far as the eastward advance of the rain area is concerned, but it does show the southward movement of the rain area along the coast. There is also a suggestion that the axis of heaviest precipitation (east of the coastal ranges) was directed northeastward across Nevada toward Idaho. West of 155° W., the upper winds had turned to northwest indicating the increasing depth of the air mass behind the wave. This in itself supported the surface evidence that the Low at 145° W. would probably be the last of the series of waves noted on the first day of the month.

In figure 3 the indications of the previous day became certainties as the belt of northwesterly winds dominated the region from the coast of northern California northwestward some 25° of longitude. With the strong belt of westerly winds extending to such low latitudes, the fronts moved rapidly inland over southern California, to produce the most intense rainfall of the five-day period. Strong convergent flow aloft, farther north, was also associated with heavy precipitation that was widespread throughout the State as shown in figure 6.

The rain ended during the night as the fronts and the trough aloft moved eastward. This was the last of the rainfall for the time being, at least, as the ocean anticyclone, now north of 35° N., continued to build and dominated the California region for the next 5 days.

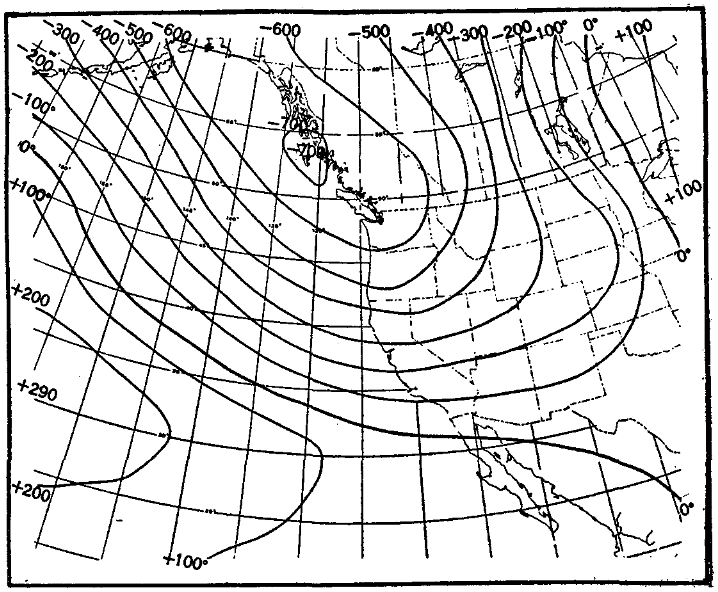

FIGURE 7.—Chart of 700-mb. height departures from normal, December 1-5, 1951. The height departures are expressed in hundreds of geopotential feet. (Enlarged copy of a portion of the original map prepared by Extended Forecast Section.)

In conclusion, an interesting example of the relationship between the upper airflow and the occurrence of precipitation, discussed by Hawkins and Martin [1], might be pointed out. They find that the value of the departure from normal of the 700-mb. heights (fig. 7) at 40° N., 120° W., plotted against the value of the departure from normal at 50° N., 130° W. minus the value at 30° N., 110° W. is related to the amount of rain that falls at Eureka during a 5-day period. It is interesting to note from their graph that the values in this case intersect at a point indicating a total of 2.00 in. or more during the 5-day period. Actually, Eureka received a total of 3.46 in. during the first 5 days of December.

REFERENCE

1. D. E. Martin and H. F. Hawkins, Jr., "The Relationship of Temperature and Precipitation over the United States to the Circulation Aloft", *Weatherwise*, vol. 3, No. 6, December 1950, pp. 138–141.

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